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2817

IN THE US PATENT AND TRADEMARK OFFICE

Appl. Number:	09/802,654
Filing Date:	03/08/01
Applicant:	Nguyen, Tranh T.
Appl. Title:	High Efficiency Switching Amplifiers
Art Unit:	2817
Examiner:	Shingleton, Michael B.

Date mailed: 03/05/02
Rohnert Park, CA

AMENDMENT

COMMISSIONER OF PATENTS AND TRADEMARKS
Washington DC, 20231

Sir,

In response to the Office letter mailed 01/14/02, please kindly consider the following applicant's arguments regarding election of species:

ARGUMENTS

The office action asked the applicant to elect a single disclosed species for prosecution on the merits to which the claims shall be restricted, or to traverse on the ground that the species are not patentably distinct.

The applicant would like to direct attention to Figure 1, which illustrates the most fundamental and generic embodiment of the invention. The fundamental concept of a controller 26 controlling the timing of both the power modulator 12 and the synchronous demodulator 16 is what makes the invented class-N amplifiers distinct from prior art, not only from the topology viewpoint but also from the principle of operation. Claim 1 clearly describes the structure corresponding to Figure 1.

Figure 2 shows an embodiment that turns out to be inoperative therefore should be deleted from the drawings.

Figures 3, 4, and 5 illustrate three class-N amplifiers implementing the fundamental structure of Figure 1, using well-known power modulators 12, namely a push-pull modulator, a half-bridge modulator, and a full-bridge modulator. They all have the same transfer function which is the product of the secondary/primary turn ratio of the transformer T1 and of the duty ratio of the

modulated pulses. The synchronous demodulators 16 in the Figures 3,4,and 5 are identical because they are designed to demodulate the same voltage waveforms produced by the secondary windings of the transformer T1.

Figures 6 to 9 illustrate more class-N amplifiers implementing the same fundamental concept of synchronous demodulation, adapted to the special case where galvanic isolation between the power source and the speaker is not a requirement. The basic configuration of the synchronous demodulator is still the same, namely an H-bridge. However the lack of galvanic isolation allows some substantial simplification in possible – although not always practical – embodiments of the H-bridge whose function is to recreate a bipolar voltage to be applied to a speaker or any other load.

Figures 10,12, and 13 illustrate other variations of the same theme of using a H-bridge as synchronous demodulator 16 with the same well-known power modulators 12, namely push-pull, half-bridge, and full-bridge, with a minor addition of the switch S7 found to be necessary to isolate the synchronous demodulator 16 from the power modulator 12 during the core reset interval of the transformer T1.

Figures 11 and 11B illustrate embodiments of class-N amplifiers using two transformers instead of a push-pull transformer which have the same number of primary and secondary windings, thus potentially more expensive, however they lead to the natural decoupling of the secondary windings from the primary windings during the off interval of the power modulator 12. The skilled in the art will recognize that all configurations belong to the family of buck converter or forward converter, which simply is an isolated buck converter. Indeed all the embodiments can be considered as clever combinations of two switch-mode power supplies with proper power steering by the H-bridge to power the load with a bipolar voltage required by an AC audio signal. The proper power steering is made possible by using synchronous demodulation. The combination of elements of buck-derived converters lead to some savings in power electronics components but unfortunately also to the need for some power steering switches such as S7 to resolve any conflict in the circulation of the currents.

Therefore the applicant submits that the fundamental structure of class-N amplifiers is based on Figure 1, with the power modulator 12 and/or synchronous demodulator 16 sometimes slightly modified with additional switches to meet functional requirements of audio amplification, namely processing of an AC signal to drive a reactive load, therefore the need for bi-directional energy transfer to and from the load. The embodiment illustrated in Figure 1 is not obvious, not to Rodriguez in U.S.Pat. No.5,986,498 or in other prior art referred to in the specification. Some of

the configurations and topologies of the many embodiments of the synchronous demodulator 16 are new because they are non-obvious simplifications or skillful topological manipulation of a conventional H-bridge to adapt them to the operation of a workable synchronous demodulator, although the transfer function of all of them is that of a buck or forward converter.

The applicant could not use claims dependent on Claim 1 alone because of the need of matching of each synchronous demodulator 16 to commonly-known power modulators 12, sometimes necessitating the addition of a synchronously controlled switch to block the flow of current that would ruin the operation of the invented structures. These additional elements represent inherent limitations to class-N amplifiers which combine more functions into fewer components for a more compact and efficient audio amplifier. However, all practical embodiments conform to the fundamental structure illustrated in Figure 1 and claimed in Claim 1, while other independent claims enumerate the specific limitations or particularities of the key elements of class-N amplifiers, namely a power modulator, an at-least-four-winding transformer, a synchronous demodulator, and a controller to synchronize all state changes of the power modulator and the synchronous demodulator. Synchronicity is fundamental in this invention as it allows in many instances zero-current-switching of the switches of the power modulator 12 and minimizes the need for snubbers usually associated with hard switching of transistors.

The applicant is aware of the fact that based upon Claim 1 or Figure 1, other class--N amplifiers can be implemented. However this can only be done with the knowledge of the embodiments disclosed in the present patent application. The applicant plans to claim these additional and possible embodiments once their implementation done and their advantages can be justified.

Please amend the above-identified application as follows:

In the Specification:

Please replace the first sentence of the 3rd paragraph of page 4 with the following rewritten sentence:

-- In a first embodiment of the amplifier of this invention, as depicted in FIG. 3, a power modulator 12 comprising a push-pull pair of switches Q5-Q6 drives the center-tapped primary winding 40 and a second push-pull pair of switches Q7-Q8 drives the center-tapped secondary winding 42 of the transformer T1. --

In the Claims:

Please replace the entire section of claims as follows: